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ABSTRACT

Described is a study which represents an attempt to investigate the construct validity and internal consistency of a Test of Logical Thinking, the reliability of the IAR scale, and the relationship between formal reasoning ability and locus of control. (Author/SA)

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# THE RELATIONSHIP OF FORMAL REASONING ABILITY AND LOCUS OF CONTROL

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# THE RELATIONSHIP OF FORMAL REASONING ABILITY AND LOCUS OF CONTROL

## INTRODUCTION

Numerous studies have reported the importance of cognitive development (e.g., Cantu and Herron, 1978) and locus of control (McGhee and Crandall, 1968) on academic achievement. Individual learner characteristics such as these may interact when their effects are examined conjointly with outcome measures such as science achievement and on-task behavior.

Recent studies (Tobin and Capie, 1979; Yeany, Dōst and Barstow, 1979; Goodstein and Howe, 1978) have confirmed the importance of cognitive development to science achievement.

Research has consistently shown that students at the concrete level have difficulty in developing abstract concepts and that the use of formal modes of reasoning enable students to achieve at a higher level on concrete and formal concepts. Thus, knowledge of the cognitive development of learners is important for researchers and teachers. Unfortunately, group tests of formal reasoning (e.g. Tisher and Dale, 1975) have tended to have low reliability. An important purpose of this study was the development of a group test of logical thinking.

The Intellectual Achievement Responsibility (IAR) scale (Crandall, Katkovsky and Crandall, 1965) measures the extent to which a student feels he is responsible for his performance on academic and intellectual tasks. Two sets of items are included in the instrument, one measuring a subject's willingness to accept responsibility for success (I+) and the other his acceptance of responsibility for academic failures (I-). Crandall et al

(1965) and Mischel, Zeiss and Zeiss (1974) reported that locus of control for success and failure appeared to be independent and each predicted specific outcomes that the other did not.

In most instances, continuous measures obtained from the IAR scale have been used as a basis for dichotomizing the variable. On the basis of test performance, subjects are rated as internal or external. In many cases a median split was used to form a dichotomy and in other instances the upper and lower 27 percent of the sample were used. Morris and Messer (1978) suggested a procedure whereby internals had to be above the median on I+ and I- and externals had to be below the median on each.

With regard to the issue of dichotomizing continuous data, Kerlinger and Pedhazur (1973, p. 241) stated that: "There are no solid principles to guide the categorization of continuous variables. It can be said, however, that one should not categorize a continuous variable because there is nothing to be gained; indeed there is a danger of loss." As a consequence, continuous measures were used in all analyses involving locus of control in this investigation.

## PURPOSE

The three main purposes of this study related to:

1. An investigation of the construct validity and internal consistency of a Test of Logical Thinking (TOLT);
2. an investigation of the reliability of the IAR scale; and
3. relationship between formal reasoning ability and locus of control.

## PROCEDURES

### Subjects

A non-random sample of students was selected from grades 7-11 in an urban high school. Tests of locus of control and formal reasoning were administered

to students in intact classes such that 102 students were tested on each measure. Fifty-three students were tested on both measures.

Instrument

Formal Reasoning Ability. Selected items from a test developed by Lawson (1978) were a basis for developing the initial version of the TOLT. Two items were selected to measure each of five modes of formal reasoning: proportional reasoning, combinatorial reasoning, probabilistic reasoning, correlational reasoning and controlling variables. The test incorporated demonstractions and students selected a correct response from a number of alternatives and provided written justification for their selection.

To ascertain whether the TOLT items were measuring a common underlying construct, an orthogonal factor analysis was conducted on the composite scores on each of the 2 item sub-tests. The procedure that was used replaced the diagonal elements of the correlation matrix of the sub-tests with communality estimates. The initial estimates were the square multiple correlation of each sub-test with the remaining sub-tests. An iterative procedure which replaced the diagonal elements with successively refined communality estimates was then used to obtain an initial factor solution. A Scree test (Cattell, 1966) and the Kaiser criterion of retaining only factors with eigen values greater than one were used to obtain a meaningful factor solution.

The internal consistency (Cronbach's $\alpha$) of the TOLT items was measured from the data.

Locus of Control. Internal consistency measures of reliability (Cronbach's $\alpha$) were obtained for the total score, I+ sub-scale and I- sub-scale.

Because of the comparatively low reliability coefficients obtained, two split-half techniques were used to obtain an estimate of the reliability of the IAR scale.

Since Crandall et al (1965) had designed the test so that it contained 17 pairs of items, the initial random assignment was based on these pairs. One item from each pair was randomly assigned to a group with the constraint that a balance between I+ and I- items was retained.

The underlying structure of the test was investigated with an oblique factor analysis. The final factor solution was obtained using a Scree test and the Kaiser criterion.

A six-factor solution which accounted for approximately 70 percent of the common variance was obtained from the factor analysis. On the basis of the factor pattern coefficients, items were paired within each factor. One item from each pair was randomly assigned to enable a split-half reliability coefficient to be calculated.

Relationship Between Cognitive Development and Locus of Control

Fifty-three pupils were tested on TOLT and the IAR scale. Analysis of their performance enabled a test of the relationship between cognitive development and locus of control. Pearson product-moment correlations were computed as a measure of the strength of the relationship between the variables.

## RESULTS

Formal Reasoning Ability

The distribution of scores obtained on TOLT is presented in Table 1.

The factor analysis indicated that a one-factor or two-factor solution was appropriate. Examination of the factor structure loadings on factor 2 indicated that the common variance for which it accounted was largely attributable to variation in proportional thinking. As a consequence, a one-factor solution which accounted for 42 percent of the total common variance was preferred.

Table 1

Distribution of Scores on Test of Cognitive Development

| Score | Number of Students |
|---|---|
| 10 | 2 |
| 9 | 0 |
| 8 | 11 |
| 7 | 7 |
| 6 | 10 |
| 5 | 11 |
| 4 | 18 |
| 3 | 16 |
| 2 | 18 |
| 1 | 10 |
| 0 | 0 |

Factor loadings from the one-factor solution indicated that four of the five sub-tests contributed significantly to the solution. The factor was termed formal reasoning. The loadings for each sub-test on this factor are presented in Table 2.

TABLE 2

Sub-test Loadings on the Factor Formal Thought

| Variable | Loading |
|---|---|
| Proportional Reasoning | 0.79 |
| Controlling Variables | 0.40 |
| Combinatorial Reasoning | 0.60 |
| Probabilistic Reasoning | 0.56 |
| Correlational Reasoning | 0.21 |

The low loading of the correlational reasoning sub-test can be attributed to the comparative difficulty of those items. The difficulty indices of the correlational thinking items was greater than .9 in each case.

The total test reliability, measured by Cronbach's $\alpha$ was found to be .74.

Locus of Control

Descriptive data for the IAR scale is presented in Table 3. One problem that is evident from the data is the small standard deviation obtained for the total scale and each sub-scale. This undoubtedly contributes to the low reliability coefficients obtained.

TABLE 3

Descriptive Data for IAR Scale and Sub-Scales

| | Mean | Standard Deviation | Reliability (α) |
|---|---|---|---|
| I+ | 12.5 | .46 | .52 |
| I- | 11.2 | .47 | .53 |
| $IAR_{TOTAL}$ | 23.7 | .44 | .67 |

The split-half reliability based on random assignment of the 17 pairs of items to separate halves produced a low correlation between the totals obtained ($r = .48$). Using the Spearman-Brown formula this is equivalent to a split-half reliability of .65. This value was consistent with that obtained using Cronbach's α.

A split-half reliability of .76 was obtained using the item pairs that were generated from the factor analysis. This is the preferred reliability coefficient because the factor analysis indicated that the IAR scale is not homogeneous.

Relationship Between Cognitive Development and IAR

The correlation between locus of control and formal reasoning ability was not significant. In each case the correlation coefficient obtained was close to zero. The data supported the null hypothesis of no relationship between the variables. This data is contained in Table 4.

TABLE 4

Correlation Coefficients for Cognitive Development and Intellectual Achievement Responsibility

| | Cognitive Development | |
|---|---|---|
| Acceptance of Success | r = 0.08 | p = 0.28 |
| Acceptance of Failure | r = -0.04 | p = 0.39 |
| Total IAR Score | r = 0.02 | p = 0.46 |

## DISCUSSION

Although the reliability of TOLT was reasonably high ($\alpha$ = .74) it was apparent that several factors were reducing validity. The major concern is that students of this age are generally unable to formulate a clear written justification for selecting a particular response. In addition, it is not possible to provide verbal cues as is done in a clinical interview setting. Because of these problems TOLT should be modified so that multiple justifications are provided as well as multiple solutions for each problem Reasons that had been volunteered by subjects on the first version of TOLT should be modified and incorporated into the test. A correct solution would require selection of the correct response and the best justification.*

Despite the problems mentioned above, the factor analysis provided support for the construct validity of TOLT. The ten items each contributed to provide a measure of formal reasoning.

The low reliability coefficients obtained using Cronbach's $\alpha$ as a measure of the reliability of the IAR scale and sub-scales indicated a lack of

*In fact, the suggested modifications have been incorporated in a revised version of TOLT (reliability = .84).

internal consistency. This was confirmed by the factor analysis. The I+, I- sub-scale structure was not confirmed by the data analysis. The sin-factor solution obtained, however, did provide a basis for estimating the reliability of the total IAR scale. The index of .75 that was obtained is quite acceptable. If the factor structure obtained in this investigation is confirmed in subsequent studies, this procedure could be utilized in preference to Cronbach's α, to calculate the reliability of the IAR scale.

The low reliability of the I+ and I- sub-scales should preclude their use in future research. A reliable measure of these constructs is needed so that effects due to variation in I+ and I- can be ascertained.

The correlation between formal reasoning ability and locus of control was close to zero. The implication of this finding is that formal reasoning ability and locus of control are unlikely to account for common variance in aptitude-treatment studies. This finding suggests that locus of control and cognitive development are ideal variables for predicting outcomes in science and for examining aptitude-treatment interactions.

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